Paleontological Research, vol. 2, no. 4, pp. 285-286, December 30, 1998

Survival of crinoid stalk fragments and its taphonomic implications: additional discussion

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Received 1 November 1998: Revised manuscript accepted 24 November 1998

Key words: Crinoids, regeneration, taphonomy

The discussion by Stephen K. Donovan (in this issue) on our paper (Oji and Amemiya, 1998) provided additional examples of extant and fossil stalked crinoids in which stalk elements have an ability to stay alive after they have lost their crowns. We are grateful for such information in other crinoid taxa. Such lines of evidence that crinoid stalk fragments (pluricolumnals), or a whole stalk, of many different taxa of crinoids can/could live for a considerable time, will certainly change our view that all incomplete body parts on the today's or ancient sea floor were completely dead at the time of burial.

We would like to mention one thing about the word "regeneration". In most cases, this word refers to the process in which the lost body part was repaired. There are a lot of records that crinoid arms, pinnules and visceral mass, if lost, can be regenerated, repaired, and often leave no traces of damage to the skeletons (Mladenov, 1983; Meyer, 1985; Schneider, 1988; Amemiya and Oji, 1992). On the other hand, the previous reports of stalk "regeneration" of 1) an Ordovician crinoid (*Lichenocrinus dubius*) by Ausich and Baumiller (1993), and 2) "regeneration" of extant *Democrinus* species by Donovan and Pawson (1998), are not true repair processes of the lost body parts but, as they described as "root-like growths", it may be called as an inaccurate regeneration on the proximal part of the stalk. The extant *Democrinus* and fossil Ordovician crinoid could not regenerate their lost crowns from the stalk alone.

With regards to the crinoid stalks, at least two different patterns of regeneration/overgrowth may be categorized as follows:

1. Regeneration—In this process the lost body parts are repaired as in the original morphology. This is observed only in the crinoid arms, pinnules, and visceral mass.
2. Overgrowth—Lost body parts are replaced by very incomplete growth of the skeleton, differing in morphology from the original. This process probably comes closer to the term "healing" rather than "regeneration". This overgrowth is documented in the proximal stalk in the decapitated specimens of extant *Democrinus* (Donovan and Pawson, 1998), Ordovician *Lichenocrinus dubius* (Ausich and Baumiller, 1993), Ordovician pluricolumnals (cited in the discussion by Donovan), and the distal end of the stalk (synostosis on the nodal facet) of some extant isocrinid species (*Endoxocrinus* and *Diplocrinus*).

In the sense as above, regeneration is only seen in the crown, and it has not been documented in the stalk (except for the cirri generation of a damaged or lost tip). On the other hand, overgowth is often seen in the stalks. The morphology of the stalk overgrowth, as Donovan pointed out, is very similar to the radicular cirri. This evidence seems to indicate that the stalk does not have the ability of regeneration as commonly understood. Therefore, in addition to the different functional morphologies and survival stragegies of the stalks in *Metacrinus* and *Democrius* as pointed out by Donovan, the response to stalk autotomy and/or breakage is also different between these two taxa.

The present note aims to clarify that there seems to be at least two different patterns in the repair process of crinoids, corresponding to their body parts. We have not started the test suggested by Donovan, if the stalk survives or regenerates after it is mechanically broken between the articulation, in the middle of a noditaxis. Further observations of such experiments will probably clarify if isocrinid stalks show different regrowth patterns from *Demoncrinus*, or if they are essentially the same. Also more work should be done on this subject in order to know the meaning of survival of such a stalk and its pluricolumnals. We thank Jay Schneider for the review of this note.

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